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Barker Reservoir
Boulder County, Colorado

National Eutrophication Survey, Corvallis, Oreg

Prepared for

Corvallis Environmental Research Lab, Oreg

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NATIONAL EUTROPHICATION SURVEY

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REPORT

ON

IRWIN RESERVOIR

BOULDER COUNTY

COLORADO

EPA REGION VIII

WORKING PAPER No. 765

WITH THE COOPERATION OF THE

COLORADO DEPARTMENT OF HEALTH

AND THE

COLORADO NATIONAL GUARD

JUNE, 1977

TECHNICAL REPORT DATA

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Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN-ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		08H 05C

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Colorado Department of Health for professional involvement, to the Colorado National Guard for conducting the tributary sampling phase of the Survey, and to those wastewater treatment plant operators who voluntarily provided effluent samples.

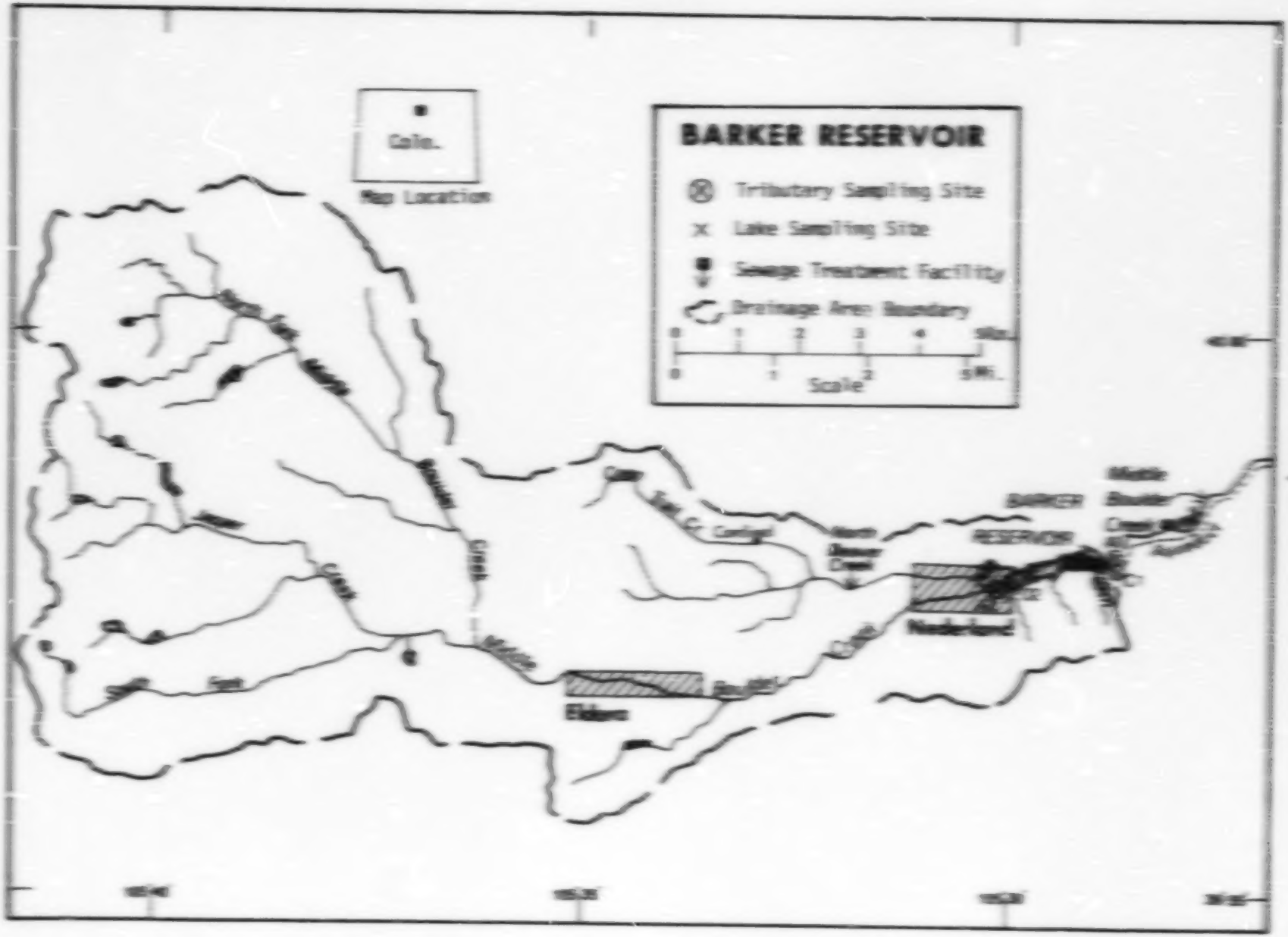
The staff of the Water Quality Control Division provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Lt. Colonel Paul A. Parsons, the Deputy Aajutant General of Colorado, and Project Officer Colonel Hershel C. Yeargan, who directed the volunteer efforts of the Colorado National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY
STUDY LAKES AND RESERVOIRS

STATE OF COLORADO

NAME	COUNTY
Barker	Boulder
Barr	Adams
Blue Mesa	Boulder
Cherry Creek	Arapahoe
Cucharas	Huerfano
Dillon	Summit
Grand	Grand
Green Mountain	Summit
Holbrook	Otero
Meredith	Crowley
Milton	Weld
Navajo	Archuleta, CO; San Juan, Rio Arriba, NM
Shadow Mountain	Grand


Colo.
Map Location
BARKER RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Drainage Area Boundary
0 1 2 3 4 5Mi.
0 1 2 3 5Mi.
Scale
RESERVOIR
Nederland
Eldora

BARKER RESERVOIR
STORET NO. 0801

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Barker Reservoir is mesotrophic. It ranked fifth in overall trophic quality when the 13 Colorado lakes and reservoirs sampled in 1975 were compared using a combination of six water quality parameters*. Five of the water bodies had less median total phosphorus and dissolved orthophosphorus, seven had less median inorganic nitrogen, three had less mean chlorophyll a, and four had greater mean Secchi disc transparency. No significant depression of dissolved oxygen occurred at depths as great as 36.6 meters.

Survey limnologists did not observe macrophytes or surface concentrations of algae during sampling visits.

B. Rate-Limiting Nutrient:

The algal assay results are not considered representative of conditions in the reservoir at the time samples were taken due to significant changes in nutrient concentrations during shipment from the field to the laboratory. The reservoir data indicate nitrogen limitation at all sampling stations and times with the exception of station 2 in May.

C. Nutrient Controllability:

1. Point sources--The wastewater treatment plant at Nederland,

* See Appendix A.

the only known point source, contributed 46.8% of the total phosphorus load to Barker Reservoir during the sampling year.

The present phosphorus loading of 0.59 g/m^2/year is more than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as an oligotrophic loading but less than his suggested eutrophic loading; i.e., a mesotrophic loading (see page 11). Any reduction of the point-source phosphorus load would be considered a measure to protect the existing quality of Barker Reservoir.

2. Non-point sources--Non-point sources contributed 54.7% of the total phosphorus input during the sampling year. Middle Boulder Creek contributed 49.7%, and the ungaged minor tributaries and immediate drainage contributed an estimated 2.0%.

The phosphorus export rate of Middle Boulder Creek was a relatively low 5 kg/km^2 during the sampling year (see page 10); the mean of the exports of the other 26 Colorado gaged and sampled tributaries was 12 kg/km^2/yr.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 1.70 kilometers².
2. Mean depth: 8.3 meters.
3. Maximum depth: >36.6 meters.
4. Volume: 14.186 x 10^6 m^3.
5. Mean hydraulic retention time: 104 days (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Middle Boulder Creek	93.8	1.550
Minor tributaries & immediate drainage -	3.7	0.058
Totals	97.5	1.608

2. Outlet -

Aqueduct	0.0	0.940
Middle Boulder Creek	99.2	0.640
Totals	99.2**	1.580

C. Precipitation***:

1. Year of sampling: 42.2 centimeters.
2. Mean annual: 32.9 centimeters.

† Table of metric conversions--Appendix D.
†† Anderson, 1974; Anonymous, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Barker Reservoir was sampled three times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first and last visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll *a* analysis. The maximum depths sampled were 36.6 meters at station 1 and 7.9 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table.

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	3.7 - 3.8	3.8	3.7	7.8 - 15.7	13.8	15.2	6.5 - 6.8	6.7	6.6
[redacted]	6.2 - 33.3	6.6	6.4	5.6 - 7.8	7.1	7.2	7.3 - 7.8	7.4	7.4
[redacted]	35. - 36.	37.	36.	27. - 32.	30.	29.	27. - 28.	28.	28.
[redacted]	6.4 - 6.8	6.7	6.7	6.9 - 9.1	8.8	8.1	7.9 - 8.5	8.2	8.1
[redacted]	23. - 26.	24.	24.	12. - 28.	11.	26.	26. - 12.	12.	12.
[redacted]	[redacted] - [redacted]	[redacted]	[redacted]	[redacted] - [redacted]	[redacted]	[redacted]	[redacted] - [redacted]	[redacted]	[redacted]
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[redacted]	5.6 - 9.3	4.5	4.8	3.7 - 3.7	3.7	3.7	4.8 - 8.2	7.5	7.5
[redacted]	1.2 - 1.3	1.3	1.3	1.9 - 2.4	2.2	2.2	2.4 - 3.8	3.7	3.7

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/07/75	1. Melosira sp.	9,734
	2. Chroomonas (?) sp.	721
	3. Fragilaria sp.	613
	4. Cryptomonas sp.	216
	5. Mallomonas sp.	72
	Other genera	108
	Total	11,464
08/26/75	1. Fragilaria sp.	1,301
	2. Spondylosium sp.	663
	3. Chroomonas (?) sp.	256
	4. Melosira sp.	104
	5. Anabaena sp.	51
	Other genera	203
	Total	2,558
10/10/75	1. Chlamydomonas sp.	6,478
	2. Melosira sp.	748
	3. Chroomonas sp.	208
	4. Oscillatoria sp.	175
	5. Cryptomonas sp.	42
	Other genera	81
	Total	7,682

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
05/07/75	1	0.6
	2	9.0
08/26/75	1	4.7
	2	3.7
10/10/75	1	8.2
	2	6.8

C. Limiting Nutrient Study:

Due to significant changes in nutrient levels in the samples during shipment from the field to the laboratory, the assay results are not considered representative of conditions in the reservoir at the time the samples were collected (05/07/75 and 10/10/75). The reservoir data indicate nitrogen limitation at station 1 and phosphorus limitation at station 2 in May; i.e., the mean inorganic nitrogen/orthophosphorus ratios were 13/1 and 19/1, respectively. At the other sampling times, the data indicate nitrogen limitation (the mean N/P ratios were 13/1 or less at both stations, and nitrogen limitation would be expected).

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Colorado National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the months of June and August when two samples were collected. Sampling was begun in September, 1974, and was completed in August, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Colorado District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads, in $kg/km^2/year$, at station A-2 (Nederland wastewater treatment plant load subtracted) and multiplying the means by the ZZ area in km^2.

The operator of the Nederland wastewater treatment plant provided monthly effluent samples and corresponding flow data.

* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Nederland	498	stab. ponds	240.7	N. Beaver Creek/ Barker Reservoir

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Middle Boulder Creek	500	49.7
b. Minor tributaries & immediate drainage (non-point load) -	20	2.0
c. Known municipal STP's -		
Nederland	455	45.3
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation** -	30	3.0
Total	1,005	100.0

2. Outputs -

Reservoir outlet -	Aqueduct	470
	Middle Boulder Creek	390
	Total	860

3. Net annual P accumulation - 145 kg.

* Treatment plant questionnaire.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Middle Boulder Creek	26,930	85.6
b. Minor tributaries & immediate drainage (non-point load) -	1,065	3.4
c. Known municipal STP's -		
Nederland	1,640	5.2
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	1,835	5.8
Total	31,520	100.0

2. Outputs -

Reservoir outlet -	Aqueduct	14,225
	Middle Boulder Creek	12,115
Total		26,340

3. Net annual N accumulation - 5,180 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Middle Boulder Creek	5	288

* See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.59	0.09	18.5	3.0

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Barker Reservoir:

"Dangerous" (eutrophic loading)	1.04
"Permissible" (oligotrophic loading)	0.52

V. LITERATURE REVIEWED

Anderson, R. Dennis, 1974. Personal communication (reservoir information and morphometry). CO Dept. of Health, Denver.

Anonymous, 1975. Water resources data for Colorado. Part 1. Surface water records. U.S. Geol. Surv., Lakewood.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

[redacted]

LAKE CODE	LAKE NAME	[redacted] TOTAL P	[redacted] DISSOL N	[redacted] SEC	[redacted] CHLOR	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
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[redacted] RANKED BY INDEX VALUE

RANK	LAKE CODE	LAKE NAME	INDEX VALUE
1	[redacted]	[redacted]	521
2	[redacted]	[redacted]	475
3	[redacted]	[redacted]	451
4	[redacted]	[redacted]	433
5	[redacted]	[redacted]	359
6	[redacted]	[redacted]	354
7	[redacted]	[redacted]	296
8	[redacted]	[redacted]	291
9	[redacted]	[redacted]	283
10	[redacted]	[redacted]	263
11	[redacted]	[redacted]	157
12	[redacted]	[redacted]	154
13	[redacted]	[redacted]	85

16

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

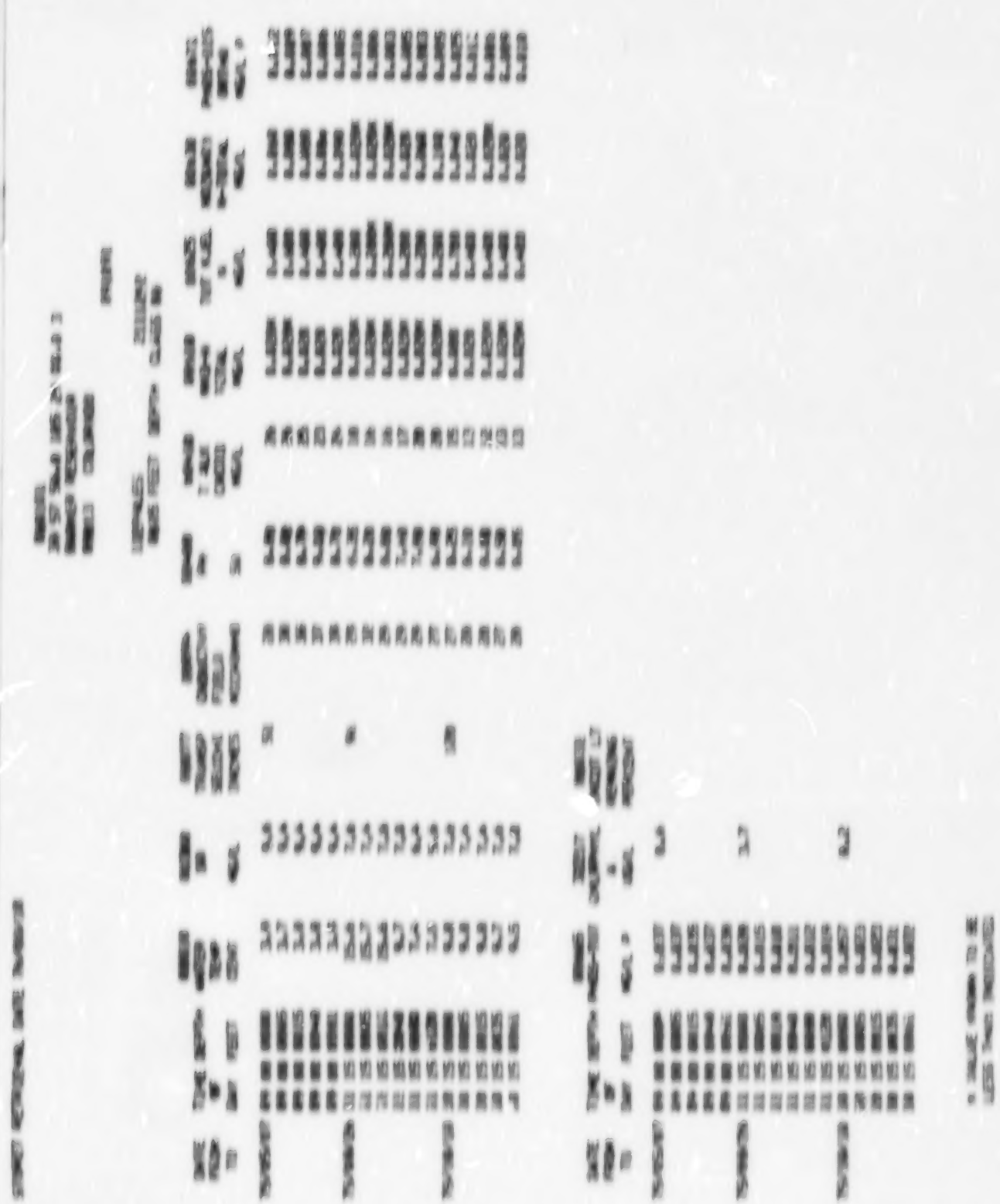
Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

APPENDIX B

PHYSICAL and CHEMICAL DATA



APPENDIX E

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

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